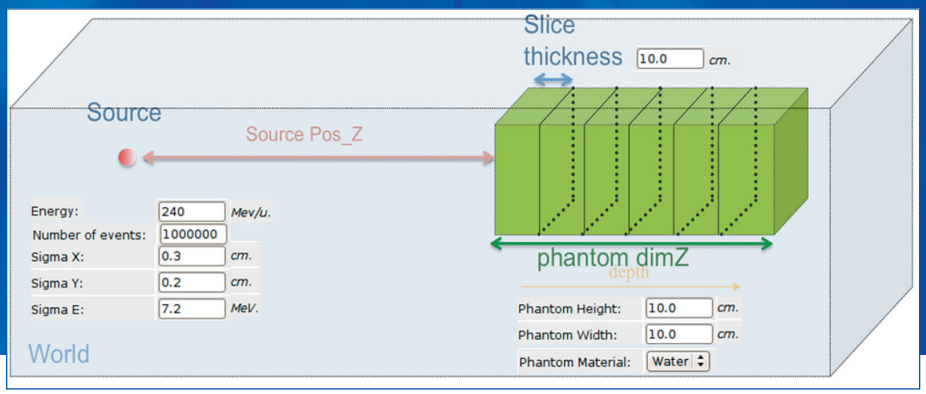
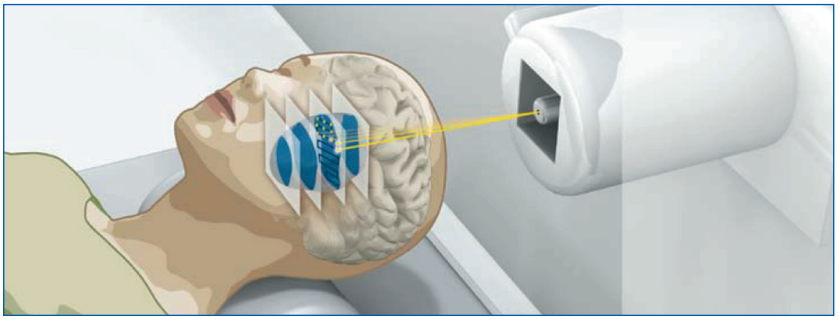
In Silico Dosimetry



What is Radiation Therapy?

Radiation therapy for cancer treatment has been in use for over 100 years. Radiation therapy, also known as radiotherapy or radiation oncology, refers to the medical use of ionising radiation for cancer therapy by controlling malignant cells. The therapy uses ionising radiation to damage DNA cells. The damage is caused directly by photons, neutrons or charged particles or indirectly through released free electrons. These free electrons can further damage DNA by breaking molecular bonds, causing ionisation or creating free radicals. The total dose is usually spread out over time. This procedure allows normal cells to recover between irradiation phases. Typical treatments involve irradiation levels of around 2 Gray per day, five days per week. There are three main divisions of radiation therapy: external beam therapy where the radiation source is outside the body; brachytherapy where a sealed source is used in the area under treatment; and unsealed source therapy given by infusion or oral ingestion. Particle therapy (also known as hadron therapy) is a special case of external beam radiotherapy where the particles are protons or heavy ions. Tumours can be located with 3D images from X-ray computer tomography (CT), magnetic resonance imaging (MRI) and positron emission tomography. The total treated volume as well is defined using the CT information on different tissues of the patient.

Radiation Therapy Studies



Courtesy Heidelberg Ion Beam Therapy Center at the University Hospital Heidelberg, Germany

Through a collaboration with the Turin based company I-SEE, a web-based module is being developed to determine high energy particle dose rates in tissue. Through Nucleonica's web interface, users can specify the simulation parameters and send those for calculation. I-SEE is active in the field of particle therapy and specialises in services for the simulation of beam delivery lines for cancer treatment for both proton and carbon ion beams. The key innovation here is through the use of a distributed Monte Carlo computing environment (based on the delocalization of resources and adopting a parallelized architecture, to minimise calculation times) and the use of web browser interface for running, checking and displaying results. With I-SEE's expertise in radiation therapy, and Nucleonica expertise in web services, browser based applications and training, the collaborative partnership is in the position to provide a unique service to oncology centres for particle and radiation therapy and to companies operating in this area of healthcare.

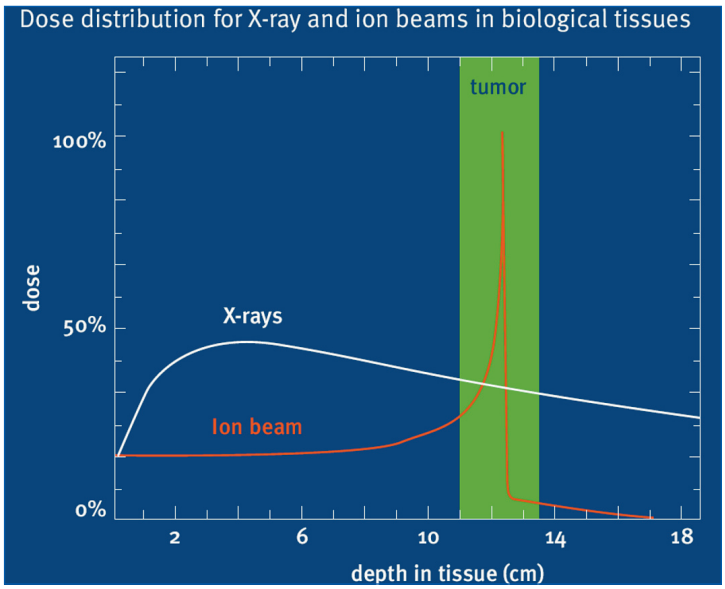
DID YOU KNOW

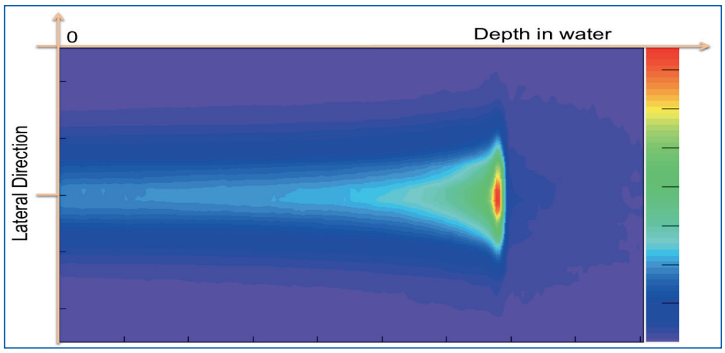
- *The in silico dosimetry module is a joint development between the Nucleonica team and I-SEE Beam Simulations (www.i-seecomputing.com).*
- *To date about 79,000 patients have been treated with hadrons in one of 30 centres worldwide (in contrast there are around 100,000 X-ray radiotherapy centres performing hundreds of thousands of treatments every day).*

Beam Simulations

are performed with a dosimetry module for calculating the energy loss in 3D for X-ray, proton and carbon ion beams. In contrast to electromagnetic radiation (X- and γ-rays), which exhibit an exponential decrease of intensity with penetration depth, heavy charged particles such as protons or heavy ions have a well defined range in matter (see diagram). The energy deposition of heavy ions is characterized by a low entrance dose and a pronounced sharp maximum near the end of range (Bragg peak). This allows treatment of the organs affected while sparing the healthy tissue. To deliver a radiation dose accurately requires high accuracy in the simulation and the treatment plan.

Heavy ion beams used in the field of hadron therapy provide additional advantages because of the radiobiological efficiency of heavy ions and especially carbon ions beams. The production of secondary particles, however, requires a very precise estimation of the fragments created and their distribution in the target volume.





Radiobiology Effect Estimates

When using heavy ion beams for radiation therapy, it is mandatory to estimate well the radiobiological effect in patients before treatment. Using the Monte Carlo algorithms, one can estimate the tissue responses to radiation and cell survival when irradiated with specific beams.